Disease Detectives

PROLOGUE

. . . During an epidemic of 1918, according to medical lore, victims were struck down almost in midstride. Four women in a bridge group played cards together until 11 o'clock in the evening. By the next morning, three of them were dead. One man got on a streetcar feeling well enough to go to work, rode six blocks and died. During the single month of October, [this epidemic killed] 196,000 people in this country—more than twice as many as would die of AIDS during the first 10 years of that epidemic...

Excerpted from Robin Marantz Henig, "Flu Pandemic." The New York Times Magazine, *November 29, 1992.*

Who were the victims? What set them apart from those who remained healthy? What caused all these deaths? Scientists, researchers, doctors, and public health officials study outbreaks of disease in order to understand how each disease is spread, what is causing it, and how to stop it. In the case of the people described above, did anyone know how the disease spread? Could anything have been done to prevent it? How did the disease actually kill? We know now that by the end of the winter of 1918–1919, two billion persons around the world had come down with influenza, also known as the flu, and between 20 and 40 million had suddenly died from a disease that seems common today. If it happened once, could it happen again?

In this first learning experience, you will examine one of the early stories in the development of our understanding of infectious disease. Major discoveries in this field, providing fundamental insight into how living organisms function, began with John Snow, an English surgeon. These discoveries have also led to greater understanding in the control of disease and the maintenance of good health. John Snow traced cases of an outbreak of the highly infectious disease cholera in an effort to

find the source. Using the following reading and excerpts from John Snow's writings, you will retrace this man's steps as he discovered preliminary answers to many of the questions about the source of the outbreak, who was affected, and what could be done to break the chain of transmission of disease.

Figure 1.1
Flu epidemic

L'ÉPIDÉMIE D'INFLUENZA. —Vue intérieure de la tente-hôpital.

READING

Cholera

In the early 1800s, England was in the throes of the industrial revolution. Until the late 1700s, most of England's workers lived in the countryside, laboring as farmers. But by 1830, the economic heart of England was in its cities where laborers, forced off of their farms, were competing for low wages in the new factory economy. Market towns could not change quickly enough to keep pace with their expanding populations. Cities had not yet invented police forces, and fire brigades services had to be bought. Housing was overcrowded. Because there was no system for collecting garbage, it piled up in streets, creating a breeding ground for vermin. Usually, raw sewage was thrown into the streets or into the nearest stream, which might be a source of drinking water. No city had an adequate clean water supply as yet. Of course,

there was no gas or electric lighting at that time. In short, the infrastructure of the modern city had yet to be invented.

By 1830, the upper and lower social classes were divided dramatically. While the desperately poor laborers struggled each day just to feed and clothe themselves, the newly rich factory owners who employed them were managing the world's most powerful empire for England and for their own profit. Poor laborers, who were paid starvation wages, feared and mistrusted the wealthy classes. In 1798, observing the overcrowding and miserable conditions in England's new cities, the economist Thomas Malthus had written about the population explosion and argued that the growth in population guaranteed that poverty and starvation would become a severe problem.

The growing number of city-dwellers created a sudden increase in the demand for medical workers. At the same time, Britain's medical students were first being required to learn about human anatomy. To help institute this requirement, the dissection of a cadaver (a human corpse) was included in the required curriculum of medical schools. The only legal source of cadavers at that time was executed criminals, and unfortunately for medical students, the number of students far outnumbered the men and women who had been hanged from the gallows. So, medical schools began hiring grave robbers to provide them with an additional supply of corpses. Most of the graves poached were graves of the indigent. To the poor, it looked as though doctors used the bodies of the underclass to do their training, then used their training to benefit the upper class.

In 1832, Parliament passed the Anatomy Act, which provided doctors with the unclaimed bodies of people who had died in workhouses, prisons, and hospitals. This law guaranteed that all the cadavers for dissection would be poor. Poor people could not afford the services of doctors. For most of the working class, the only contact they could expect to have with a doctor happened if they were stricken in an epidemic and forcibly dragged to an unsanitary public hospital for "treatment;" in that case, they could expect to die in the hospital. With the passage of the Anatomy Act, it appeared to many of Britain's poor that the rich medical doctors were going to add insult to injury by interfering with their traditional, religious burial—literally by robbing their graves for "science." While the poor mistrusted the motives of the medical profession and the rest of the "better" classes, the educated upper classes generally saw the attitudes of the poor towards the medical profession as proof of their ignorance and irrationality.

In 1826, a *pandemic* (a disease occurring among many individuals worldwide, in contrast to an *epidemic,* a disease that occurs among individuals locally) of the dreaded disease cholera had begun in India. It was observed there by British physicians and tracked as it made its way first to Russia by 1830, then to the Austro-Hungarian Empire by 1831.

Cholera killed 100,000 people along the Danube River before making its way into Western Europe. Then, in 1832, in the same year that the Anatomy Act was passed, the cholera disease found its way to the shores of Britain.

At first, the reports of cholera aggravated English class tensions. Doctors reported that in Europe, cholera's victims were generally from the poorer classes. Conspiracy theories emerged. Some believed that cholera was a big profiteering hoax, drummed up by the grave-robbing doctors to scare people into buying medicine. Others believed that cholera was not a disease at all. They thought the government (which was, after all, in the hands of England's wealthiest citizens) had decided to poison the wells of the poor, to kill the "surplus population" which Malthus had predicted.

Gruesome descriptions of the disease helped to fuel the panic and mistrust. Many victims died rapidly after experiencing terrifying symptoms. Often, the victim would feel absolutely healthy one minute, and the next, feel extremely nauseated. This nausea would be followed by a sudden and total evacuation of the bowels. From here, the victim would have the sensation of a great weight around the waist and a prickly sensation in arms and legs. Cold, clammy sweats would begin, together with a suppressed pulse and severe headache. Within one

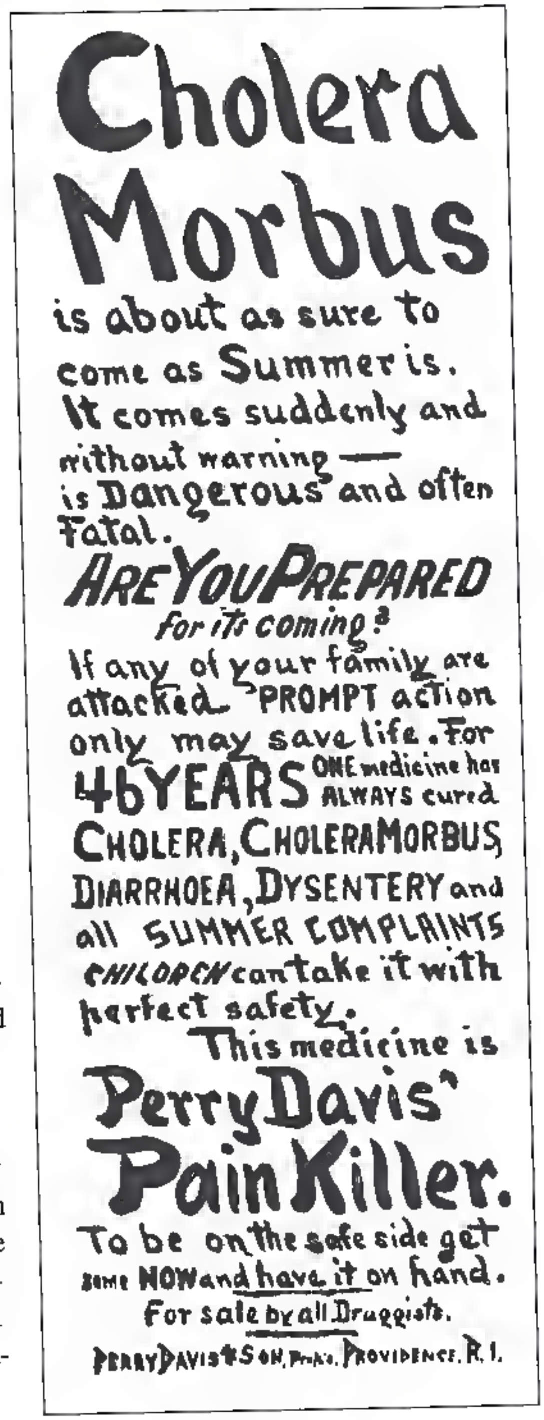

Figure 1.2
Was there a cure? "Morbus" was a synonym for "disease."

hour of the disease's onset, a person's bowel movements would produce an odorless liquid, filled with rice-like pellets (doctors later determined that this "rice" was actually fragments of the victim's intestinal lining). Soon, the patient's body would shrink and shrivel. Acute cramps would begin in the fingers and toes and then spread to the rest of the body. Skin would turn blue or black. Death generally occurred within two to seven days.

No one knew the cause of the disease, but doctors had a variety of theories. Some believed that it was carried on the air by an unhealthy "effluvia." These "effluvyists" suggested that the effluvia was exhaled by those who were already ill. Others, "miasmatists," believed that the garbage and feces covering streets of the overcrowded cities produced some kind of deadly vapor or miasma which, when inhaled, caused the cholera. Other theorists believed that an unhealthy diet was the cause. Still other beliefs included unclean water, or the "immoral drunkenness" and "dirty habits" of the poor. Some suggested that there might be a chemical contaminant causing the illness. Some said the disease was a punishment from God, and that there was nothing to be done to stop it.

It was in this social and scientific context that John Snow, in 1832, an 18-year-old surgeon's apprentice, had his first experiences comforting the dying victims of cholera.

After the 1832 pandemic, cholera did not return to Britain until 1848. By the time it returned, Snow had become one of the most famous surgeons in England. He had become a leading pioneer in the use of surgical anesthetics (a brand new invention), and had become a personal physician of Queen Victoria. In the sixteen years since 1832, the class tensions in England had, if anything, become worse. The medical profession was still arguing over the causes of cholera and the public's feelings about it had not improved. But one major new idea had been introduced to the medical world. Though no one had yet proved it, a few radicals were suggesting that some diseases might be caused by microbes. John Snow knew of this idea, and he thought it might be true.

ANALYSIS

1. Consider the conditions whicb existed in England in the 1830s. What do you think contributed to the outbreak of cholera?
2. Give some reasons why most cholera victims came from the lower class.
3. Why do you think the cholera epidemic stopped in 1832?
4. Thc cholera pandemic began in India in 1826. How do you think a disease spreads across continents and around the world? Do you think this happens today? More or less frequently? Why?

ACTIVITY

Investigating the Nature and Cause of Cholera

INTRODUCTION John Snow had three opportunities to study cholera: first in the pandemic of 1832, again in the epidemic of 1848–1849, and finally in the epidemic of 1853–1854. In 1854 he published "On the Mode of the Communication of Cholera," in which he outlined all of his discoveries. In his work, Snow presented the evidence he had collected and then used that evidence to draw conclusions.

You are going to begin a scientific analysis of data in order to solve the mystery of cholera by examining precisely the same evidence that was available to Snow in 1854. You will be reading six separate sets of excerpts from Snow's writing. As you read the data sets, think about the following:

- To solve the mystery as Snow did, you will have to use the tools of 1854. You will have no microscope.
- In one respect, your job will be far easier than Snow's. Snow had to collect all of the evidence, sort through it, and figure out which evidence was relevant to his study. All you have to do is examine the evidence that he had already determined to be relevant, and analyze it.
- When Snow began, he had already heard two decades of medical debate about the possible causes of cholera. Like many scientists, he began with a hypothesis. Then he went out to find the evidence necessary to test his hypothesis.

In John Snow's day, doctors were searching for the answers to several crucial questions:

1. How did cholera spread?
   - Were the effluvia or miasma theories correct?
   - Was the disease spread by some other means?
   - Could the disease spread by a variety of methods?
2. Why did some of the people exposed to victims of cholera get sick, while others did not? Why were the poor especially vulnerable to the disease?
3. Could the spread of cholera be prevented? If so, how?
4. Once a person had cholera, could he or she be treated? If so, how? (John Snow did *not* discover the answer to this question. It was answered later by other researchers. But by the end of this learning experience, you should be able to make an educated guess (*hypothesis*) about the answer to this question.)

5. What was the *underlying* cause of the disease? (John Snow could not prove his answer to this question, but he made an educated guess that turned out to be correct. What do you suppose he hypothesized?)

TASK

Read Data Set I. After reading it, stop and fill in the Data Analysis chart by completing the following two steps.

1. Determine which of the questions listed can be answered using the information given in the Data Set you have just read. Then, write the answers that can be derived from the data in the row labeled "hypothesis." In other words, answer the questions with your own hypotheses (possibly your hypotheses will be similar to those developed by Snow). If a question is not addressed in the data set put N/A for "not applicable" in the appropriate box below the question.
2. Think carefully about the information from the excerpted data. If possible, show how the data presented so far are inconclusive. In other words, even if the data point toward a particular answer to any of the five questions, other answers might still be possible. Look for these "holes" in the proof of your hypothesis and record your ideas in the row labeled "Reasons data may be inconclusive."

Proceed to the second data set, read it, and fill in that part of the chart. You may need to refer back to material you have already read. Follow the same procedure until you have finished Data Set 6.

READING

Snow on Cholera

Excerpts adapted from the original, as reprinted in How We Know: An Explanation of the Scientific Process, *by Martin Goldstein and Inge F. Goldstein, Plenum Press, NY, 1978.*

DATA SET 1 When it appears on a fresh island or continent, cholera always strikes first at a seaport.

It travels along highly populated areas, never going faster than people travel, and generally much more slowly.

It never attacks the crew of a ship sailing away from a country that is free of cholera.

DATA SET 2 I called recently to ask about the death of Mrs. Gore, the wife of a labourer, from cholera, at New Leigham Road, Streatham. I found that a son of the deceased had been living and work-

ing at Chelsea. He came home ill with a bowel complaint, of which he died in a day or two. His death took place on August 18th. His mother, who attended to him, was taken ill on the next day, and died the day following (August 20th). There were no other deaths from cholera registered in any of the metropolitan districts, until the 26th of August, within two or three miles of the above place . . .

* * *

John Barnes, aged 39, an agricultural labourer, became severely ill on the 28th of December 1832; he had been suffering from diarrhea and cramps for two days previously. He was visited by Mr. George Hopps, a respectable surgeon at Redhouse, who finding him sinking into collapse, requested an interview with his brother, Mr. J. Hopps of York. This experienced practitioner at once recognized the case as one of Asiatic cholera . . . He immediately began investigating for some probable source of contagion, but in vain; no such source could be discovered.

While the surgeons were vainly trying to discover where the disease could possibly have come from, the mystery was all at once, and most unexpectedly, unraveled by the arrival in the village of the son of the shoemaker, living at Leeds. He informed the surgeons that his uncle's wife (his father's sister) had died of cholera two weeks before that time, and that as she had no children, her clothes had been sent to Monkton by a common carrier. The clothes had not been washed; Barnes had opened the box in the evening; on the next day he had fallen sick of the disease.

During the illness of Mrs. Barnes, [the wife of John Barnes: she and two friends who visited Barnes during his illness also got cholera], her mother, who was living at Tockwith, a healthy village 5 miles distant from Monkton, was asked to attend her. She went to Monkton accordingly, remained with her daughter for 2 days, washed her daughter's linen, and set out on her return home, apparently in good health. While in the act of walking home she was seized with the malady and fell down in collapse on the road. She was carried home to her cottage and placed by the side of her bedridden husband. He, and also the daughter who lived with them, got ill. All three died within 2 days. Only one other case occurred in the village of Tockwith, and it was not a fatal case . . .

It would be easy by going through the medical journals and works that have been published on cholera, to quote enough cases similar to the above to fill a large volume.

* * *

Nothing has been found to favor the spread of cholera more than a lack of personal cleanliness, whether arising from habit or a shortage of water . . . The bed linen nearly always becomes wetted by the cholera evacuations, and as these do not have the usual color and odor of diarrhea, the hands of the person waiting on the patient [usually a woman,

in England in 1850] become soiled without their knowing it. Unless these persons are scrupulously clean in their habits, and wash their hands before taking food, they must accidentally swallow some of the excretion and leave some on the food they handle or prepare, which has to be eaten by the rest of the family who, amongst the working classes, often have to take their meals in the sick room. Hence the thousands of instances in which, amongst their class of the population, a case of cholera in one member of the family is followed by other cases, whilst medical men and others, who merely visit the patients, generally escape . . .

On the other hand, the duties performed about the body, such as laying it out (for the funeral), when done by women of the working class, who make the occasion one of eating and drinking, are often followed by an attack of cholera . . .

* * *

When, on the other hand, cholera is introduced into the better kind of houses . . . it hardly ever spreads from one member of the family to another. The wealthy constantly use the hand-basin and towel, and their kitchens and bedrooms are separated.

DATA SET 3 Cholera invariably begins with the affliction of the (digestive) canal. The disease often proceeds with so little feeling of general illness, that the patient does not consider himself in danger, or even [ask] for advice, till the [illness] is far advanced . . .

In all the cases of cholera that I have attended, the loss of fluid from the stomach and bowels has been sufficient to account for death, when the poor diet and health of the patient was taken into account, together with the suddenness of the diarrhea, and the fact that the process of absorption of water in the digestive tract appears to be suspended during the illness.

A period of time passes between the time when the cholera poison enters the system, and the beginning of the illness. This period is called the period of incubation.

DATA SET 4 In 1849, there were in Thomas Street, Horseleydown, two rows of houses close together consisting of a number of small houses or cottages inhabited by poor people. The houses of the two rows were back to back . . . with a separating space between them, divided into small back yards in which were located the outhouses of both the courts. These outhouses drained into the same trench that flowed out to an open sewer that passed by the far end of both house rows. In one row of buildings, the cholera committed fearful devastation, while in the adjoining row, there was only one fatality and one milder case of the disease. In the former row of houses, the slops of dirty water poured down by the inhabitants into a channel in front of the

houses and got into the well from which they obtained their water. In the latter houserow, water was obtained from a different well.

* * *

Dr. Thomas King Chambers informed me that at Ilford in Essex in the summer of 1849, the cholera prevailed very severely in a row of houses a little way from the main part of the town. It had visited every house in the row but one. The refuse which overflowed from the out-houses and a pigsty could be seen running into the well over the surface of the ground, and the water had a nasty smell, yet it was used by all the people in the houses except for the one woman who escaped the cholera. That house was inhabited by a woman who took in linen to wash, and she, finding that the water gave the linen an offensive smell, paid a person to fetch water for her from the pump in the town, and this water she used for culinary purposes as well as for washing.

READING

The Investigation Continues

What are your ideas about the evidence presented so far? Do you feel it is adequate to answer accurately the questions posed at the beginning of the Task? John Snow did not feel he had enough evidence. He therefore carried out the following two separate experiments, which revolutionized medicine. Think about the following as you read the next two Data Sets.

- What does the information Snow collected prove?
- What holes remain in the data which are needed to support the hypothesis?

DATA SET 5 In 1849, a particularly terrible outbreak of cholera occurred along Broad Street, near Golden Square, in London. Over a 10-day period, almost 500 people died there within 250 yards of the intersections of Broad and Cambridge streets. At this intersection, there was a particularly popular public water pump—well known for the good taste of its water. By the time of this catastrophe, based upon the anecdotal evidence summarized in Data Sets 1–4, Snow was more or less certain that cholera could be transmitted through the water supply. He believed that the water at the Broad Street pump must have been contaminated.

To prove his hunch, he went to the London General Register Office and got the names and addresses of the 83 people whose deaths had been recorded there. Then, going door to door, he collected information about the water-drinking habits of all the cholera victims in the area. He produced the following chart:

83 deaths					
73 living near Broad Street pump			10 not living near pump		
61	6	6	5	3	2
Known to have drunk pump water	Believed not to have drunk pump water	No information	In families sending to pump for water	Children attending school near pump	No information

Snow next gave two sets of data that strongly support the role of the pump. There were two groups of people living near the Broad Street pump who had very few cases of cholera: the inhabitants of a workhouse (where homeless people were housed and given labor to do—as Oliver Twist was) and the employees of a brewery. Snow interviewed the manager of the brewery and discovered that the brewery gave free beer to its employees and had its own well. The manager was certain that his employees did not, in fact, use the Broad Street pump at all.

As soon as Snow informed the city officials of his data, they had the handle of the Broad Street pump removed. By this time, the cholera epidemic had more or less died down of its own accord. But the simple act of removing the pump handle was the first time in world history that a public health measure was taken as a direct response to scientific data.

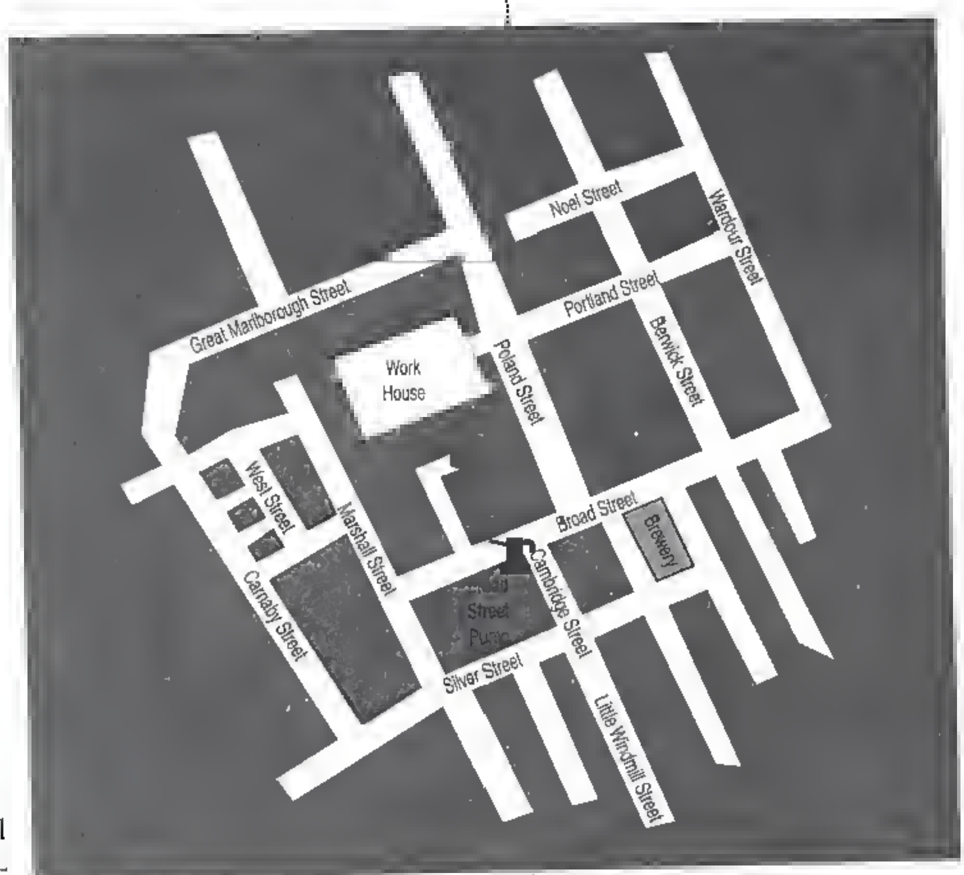

Figure 1.3
Map of the Broad Street area

DATA SET 6

Finally, in the epidemic of 1853–1854, Snow performed one more experiment. In London at this time, there was still no public water supply. However, since 1832, the city had grown tremendously, and entrepreneurs had begun to sell water door to door. Water companies ran pipes (sometimes wooden; sometimes lead) along streets in some neighborhoods, and the residents could buy water that was brought through these pipes. If a homeowner bought the water, a pipe would be run from the street main

into the front entrance of the home. This was much more convenient than having to run to the neighborhood pump as people had done on Broad Street. In many neighborhoods, two different companies competed door to door to sell their water. Thus, Snow could compare the relationship between water supply and cholera deaths both in different neighborhoods and within similar neighborhoods.

Snow did a tremendous amount of work, going door to door to see if there was a relationship between the type of water a person drank and their risk of getting cholera. The results of his work were summarized in the following chart:

	Number of houses	Death from cholera	Deaths per 10,000 houses
Southwark & Vauxhall Co.	40,046	1,263	315
Lambeth Company	26,107	98	37
Rest of London	256,423	1,422	59

Based upon the chart, Snow went on to calculate the death rate per 10,000 for those persons receiving their water from the Southwark and Vauxhall Co. and the death rate for those persons receiving their water from the Lambeth Co. See if you can make the calculations yourself. What do you conclude?

It turned out that after the 1849 epidemic, the Lambeth Company had moved the intake for its water pipes to a part of the Thames River upstream from where London's sewage poured into the river. The Southwark and Vauxhall Co. had not—its pipes still brought in water containing London sewage.

ANALYSIS

1. In the clearest language possible, write a hypothesis about how cholera spread. Using all the information accumulated by John Snow up to 1854, explain how these data support your hypothesis.
2. After 1854, what important questions still remained to be answered about cholera?
3. Describe how you might go about conducting a study to determine the cause of the disease in the following fictional community. Include what you would need to see, the questions you would ask, and data you might collect.

Desiduous is a small town, famous for its Desiduous Pickles. However, in 1991, economic times were tough. Recession meant less money and less money meant fewer pickles on the American plate. Economic problems were nothing new to Desiduous, whose town motto was, "As goes the American economy, so goes the pickle."

On Monday, July 20, however, Desiduous' distress was more than economic. Two previously healthy prominent male citizens, ages 35 and 42, had died mysteriously within twenty-four hours and panic flowed through the town like juice from a shattered pickle jar.

Roscoe Clayman, the owner of the town multiplex theater, was a respected bowler and avid tuba player. Reginald Willowslip was unemployed, a retired pickle taster in the local factory who kept his taste buds in shape at the local saloons and pubs. The only thing these two men seemed to have in common was being avid philatelists. Both had recently attended the Annual Stamp Collectors' Convention in Topeka, held at the beautiful and elegant Colossus Hotel.

In fact, across Kansas at this time, stamp collectors were falling ill and dying at an alarming rate. Within a three week period, 183 cases of the so-called Stamp Collectors' Syndrome were reported. After the first week of this apparent outbreak/epidemic, the Centers for Disease Control agency in Atlanta was contacted and six young and eager epidemiologists rushed to the scene to begin intensive and extensive investigations.

EPILOGUE

READING

It is appropriate that a discussion of the nature of disease begins with the story of John Snow. In fact, this is true for two reasons: First, Snow's work was a pioneering effort to combine scientific medical inquiry with statistics—already a critical innovation in the history of science and medicine. Second, Snow's study is one of the first recorded in the field of *epidemiology*, a discipline that documents epidemics and attempts to determine the causes. Snow's research is also a proper place to begin our study of disease.

During the time of John Snow, cities lacked public sewage systems and clean water supplies. They also lacked police departments, fire departments, paved road systems, gas, and electricity; in other words, the urban world of the early industrial revolution was a dirty, chaotic place. Unless one had the money to purchase these services through a private company, life in the city was a dismal prospect.

But Snow's work was a catalyst to change all of this. Once there was scientific, statistical proof linking disease to dirty drinking water

and untreated sewage, tremendous new pressures were placed upon city governments to manage these problems. To build city-wide sewage disposal and treatment systems meant that the city governments in Europe and the United States had to be better organized. Taxes had to be raised to pay for new construction projects. A chain reaction began. Once city governments began to take responsibility for sewage and water, it was a natural step to garbage collection, police and fire protection, and other services the industrialized world now takes so much for granted that we refer to them as "basic services."

Figure 1.4
"Death's Dispensary" by George John Pinwell, 1866, reproduced with permission from Philadelphia Museum of Art: SmithKline Beecham Corporation Fund.

The introduction of these infrastructure systems, making urban life better for everyone, reduced some of the class tensions in Britain. Finally, medicine and government made some changes that tangibly improved the lives of the working classes. Tensions did not disappear, but by the late 19th century, the unhealthy and miserable conditions of the urban poor had been substantially reduced.

Today, it is hard for Americans to imagine life without these "necessities." Just 140 years ago, it was hard for most people to imagine life with them. Infrastructure has changed the deepest fabric of our lives. But to suppose that such changes have been universal would be naive. While the vast majority of Americans no longer have to worry about the risk of cholera, outbreaks of the scourge continue to occur around the world. In much of the world, the wealth needed to build even the most rudimentary water supply and sewage disposal systems is lacking. Indeed, recent outbreaks of cholera in Latin America and Africa have spurred massive new efforts to build such infrastructure in many of the countries where these outbreaks occurred. Perhaps history is repeating itself.

EXTENDING IDEAS

- Read stories about other disease detectives. Compare one of these stories to John Snow's story including the society in which it occurred, the evidence, the techniques used, prior knowledge of the researcher, and what the impact of the discovery was on the spread of disease. The powerful story of HIV, for example, is described in numerous books, magazines and newspaper articles.
- Find out what the Centers for Disease Control and Prevention (CDC) agency does, what its role is, what techniques they use, and what kinds of jobs people do in the organization.

ON THE JOB

WATER POLLUTION CONTROL TECHNICIANS Are you concerned with the quality of the water you drink or the air you breathe? Pollution control technicians conduct tests and field investigations to determine ways to both monitor and control the contamination of freshwater, of the air, or the soil. Two major specialties of technicians are water pollution control and air pollution control. Although some technicians may specialize in noise, light or soil pollution. Water pollution control technicians help identify sources of water pollution and ways to reduce it. They collect water samples and perform physical and chemical tests in order to collect data such as temperature and turbidity; streak plates to determine the concentration of bacterial contaminants; record results; and read and interpret charts, graphs and tables. Technicians usually have an understanding of the usual environment (the air, water, soil, and so on) in which the data is collected in order to detect the presence of gases or particles which are not normally present and discriminate between the importance of pollution factors. Technicians usually have either a two year college degree in physical sciences or two year post high school training in pollution control technology. Since this is a relatively new field, some positions with on-the-job training are available to those with a high school diploma and appropriate experience. Classes such as mathematics, chemistry, physics, biology (conservation or ecology), computer courses, and English are recommended.